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Tapping panel diagnosis, decision support tool for more sustainable rubber tapping system

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Abstract –
The difficulty involved in performing an agronomic diagnosis of a tree crop is obtaining an accurate picture of current and past cultivation practices, to be able to assess their impacts on the agro-ecosystem as well as on sustainability.
As latex harvesting involves tapping the bark, which leaves scars on the trunk, we hypothesised that these morphological traces would be good indicators of current and past practices and would thus enable a diagnosis based on the economic lifespan of plantation. To this end, we formalized a tapping panel diagnosis that involved reproducing the scars on tapping panel diagrams, and analysing them using two indicators: the amount of virgin bark consumed and the number of tapping years that remained. We characterised eight tapping management systems reflecting different levels of tapping intensity. Assessment of the respective share of each tapping practice on virgin bark consumption revealed major effects of tapping frequency and of shaving thickness. We showed that, used as a decision support tool, the tapping panel diagnosis can increase remaining tapping years. To conclude, the tapping panel diagnosis will be a useful support for the participatory development of innovating tapping management schemes involving both technicians and smallholders.

Keywords *Hevea brasiliensis* - Natural rubber - Latex – Diagnosis tool - Sustainability - Smallholder - On-farm research – Economic lifespan

1. Introduction

Today, whatever the crop produced and the farming area of the world, agronomists and farmers are expected to both assess cropping systems and to design management practices to achieve sustainable agriculture (Lichtfouse et al., 2009). These expectations have led researchers to design diagnostic methods to identify the origin of an agronomic problem after the event (Doré et al., 1997; Doré et al., 2008) and, when necessary, to provide tools to help farmers to make technical decisions (Meynard et al., 2002; Chatelin et al., 2005) at the scale of both the plot and the territory (Nesme et al., 2010).
Many studies have been conducted on annual crops with the aim of reconstructing past cultivation practices (Gras et al., 1989; Doré et al., 1997; Affholder et al., 2003; Le Bail and Meynard, 2003). But fewer studies have focused on perennial crops. Moreover, good research conditions are seldom found s in tropical regions where smallholders do not keep records of their practices or of yield, either for annual or perennial crops.
In the case of rubber trees, observation of consumed bark area can provide essential and reliable information about the technical history of the plot (Fig.1).
Agro-industrial experts, who study the links between the tapping management and the physiological condition of rubber trees, are accustomed to observing the bark and "reading" tapping panels to interpret latex production and to perform agronomic diagnosis. However, this method is not suitable for smallholders, at the moment. We thus hypothesized that extending and formalizing agro-industrial know-how could help develop a diagnostic tool which would focus primarily on bark management and its impact on the economic lifespan of plantations. To be easy to use, the tool would require easily accessible data: bark observation and tapping panel analysis. As a decision support tool, it would help smallholders evaluate their technical choices and the potential consequences of their choices for the sustainability of the plantation (Michels 2005).

To this end, our study aimed to (*i*) formalize the principles of tapping panel diagnosis, and (*ii*) validate the tapping panel diagnosis as a decision-support tool with the aim of helping smallholders to adopt more sustainable tapping systems.

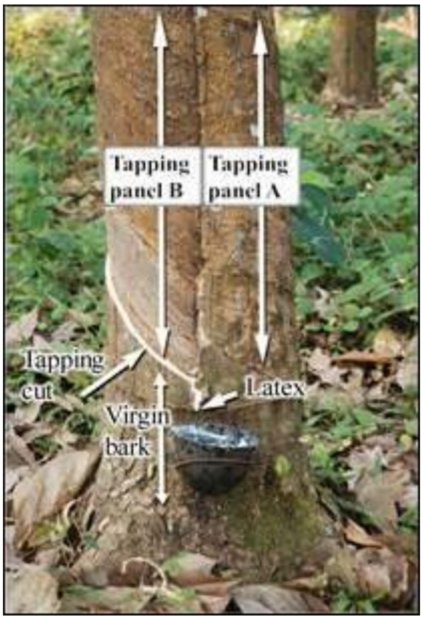

Fig. 1 Rubber tree latex is extracted using a multi-annual tapping system, which consists in using a gouge or a knife to cut away successive thin slices of trunk bark (bark shaving) at regular intervals. Tapping leaves scars on the bark of the trunk. In the figure, tapping is conducted in a downward half spiral; the trunk is then separated into two tapping panels, A and B.

2. Materials and methods

2.1. Rubber tree tapping

Figure 1 shows the tapping panel, *i.e*. the area of bark where the tapping cut is made. The tapping frequency used by the farmer can be deduced by looking at the tapping panel.

Tapping management includes opening height, cut length, tapping frequency, and the order of panel consumption. The tree is usually tapped in two stages. The first stage involves downward tapping on the lower part of the trunk for ergonomic and productivity reasons as it leaves the upper section of trunk enough time to reach a satisfactory circumference for tapping. A downward tapping cut of a half-spiral (S/2) is considered to be the best compromise between yield and sustainability (Compagnon, 1986). Once the lower panels have been consumed, the upper section of the trunk can be tapped upward: this is the second stage, which starts at the height of the first cut made for downward tapping For upward tapping, Commère and Eschbach (1988), Obouayeba et al., 2009 determined a length of a tapping cut of a quarter spiral (S/4) as the best compromise between plot productivity and sustainability).

2.2. Tapping panel diagnosis: indicators designed to read and analyse the panel history

The panel histories were drawn starting from the average bark consumption on 15 trees. These 15 trees, tapped by the same tapper, were selected randomly in each plot. Trees on which tapping was stopped temporarily or permanently because of bark dryness were disregarded for analysis.
We estimated the economic sustainability of each plot using three indicators belonging to the tapping panel diagnosis: virgin bark consumption (VBC) (1), annual bark consumption (ABC) (2), and the number of remaining tapping years (RTY) on virgin bark (3).

$$(1)\ \text{VBC}\ (\%\ y^{-1}) = \text{CVB}/\text{TVB} * 100$$

where,
CVB is the height (in cm) of consumed virgin bark measured at diagnosis,
TVB is the height (in cm) of total virgin bark available for consumption when the trees were first opened for tapping
VBC is expressed per tapping year (% y^{-1}) so as to be able to compare plots of different ages.

$$(2)\ \text{ABC}\ (\text{cm year}^{-1}) = \text{ST} * \text{nTC month}^{-1} * \text{nTM year}^{-1}$$

where ST (cm) is bark shaving thickness,
nTC month^{-1} is the number of tappings per month; this number is directly linked to the tapping frequency and to the number of working days per week (6 days in our study areas: 6d/7),
nTM .year^{-1} is the number of tapping months per year; this number is directly linked to the interruptions in tapping over the year: we took into account interruptions during rubber tree defoliation and, in some areas, during the rainy season. This variable was obtained from interviews with the farmers.

$$(3)\ \text{RTY (remaining tapping years)= RVB (cm)/ABC}$$

Where RVB (cm) is the height of the remaining virgin bark calculated from the panel history.
When we used RTY to compare different tapping management systems but wanted to avoid variations due to the differences in the skill of the individual tapper, we calculated ABC using a shaving thickness of 2 mm. When ST was tested as an explanatory variable of VBC, we evaluated the true average by computing ST on a sample of 15 trees.
Although the tapping models allow for a return to tapping on regenerated bark, we considered only virgin bark for two reasons: (*i*) at the time of the survey only two plots were being tapped on regenerated bark, and (*ii*) the possibility of a return to regenerated bark depends on the quality of tapping on virgin bark.

3. Results and discussion

We were able to summarise the variability observed across our plot sample, 25 rubber farms, by using three tapping system parameters. These parameters, which are known to influence latex production, also influence the economic life span of the trees and their future production potential:

- the number of tapping cuts: several simultaneous cuts vs. respecting recommendations which limit tapping to one cut at a time (Anekachai, 1989);
- the length of the cut: exceeding recommended length vs. respecting recommended length; this was particularly the case for upward tapping where many farmers used S/2U vs. the recommended S/4U;
- the tapping frequency: increasing tapping frequency vs. respecting recommended frequency.

We also considered the bark shaving thickness. Although it reflects the tapper’s technical skill more than a technical choice, this parameter may explain the variability of virgin bark consumption (VBC).

3.1. Testing bark diagnosis as a decision-support tool

In previous work Michels et al. 2012, showed that tapping panel diagnosis can be used as a decision-support tool to: (*i*) identify innovations to be introduced in the different plots in terms of tapping panel management, and (*ii*) simulate their impact on remaining tapping years (RTY). For that purpose, we considered four main possible changes, including results already published in the specialized literature:

- reducing tapping frequency (d4), taking into account the generalised use of hormone stimulation in the study area with specifications adapted to low tapping frequencies (Lacote et al., 2010);
- reducing tapping cut length in upward tapping (S/4) (Commère and Eschbach, 1988);
- abandoning double cuts (Anekachai, 1989);
- using a more rational succession of panels mainly implies the complete consumption of lower panels before starting upward tapping; indeed, yield from the bottom panels is lower when the bark on the upper panels is already being consumed. Consumed panels reduce sugar availability in latex regeneration areas (Lacote et al., 2004).

On the basis of this knowledge, tapping panel diagnosis can be used in two ways. It makes it possible to analyse sustainability of opened plantations through a two-step approach:
In a first approach, (i) we first calculate the remaining tapping years (RTY) in the case of a continuation of the current practices, (ii) we identified innovations to be introduced in the current tapping system and (iii) we calculate the benefit of remaining tapping years obtained. We tested this way of using tapping panel diagnosis of smallholdings (Michels et al. 2012).
As a result, two factors appeared to have an impact on the increase in virgin bark height (Fig. 2). The main factor was the adoption of S/4 in upward tapping (Michels et al. 2012). However, two other parameters may limit its application: the degree of bark consumption on the upper panels and the previously used cut length. We also showed that reducing the original several cuts to only one was the other main way to increase virgin bark height. We showed that such changes in practices could extend the remaining tapping time by 33% to 355%.

The second way to use tapping panel diagnosis consists in defining before starting an innovating system and calculating the benefit brought by the innovating tapping system on the total virgin bark amount (i.e. RVB before starting tapping) in comparison with that used in the zone of study.

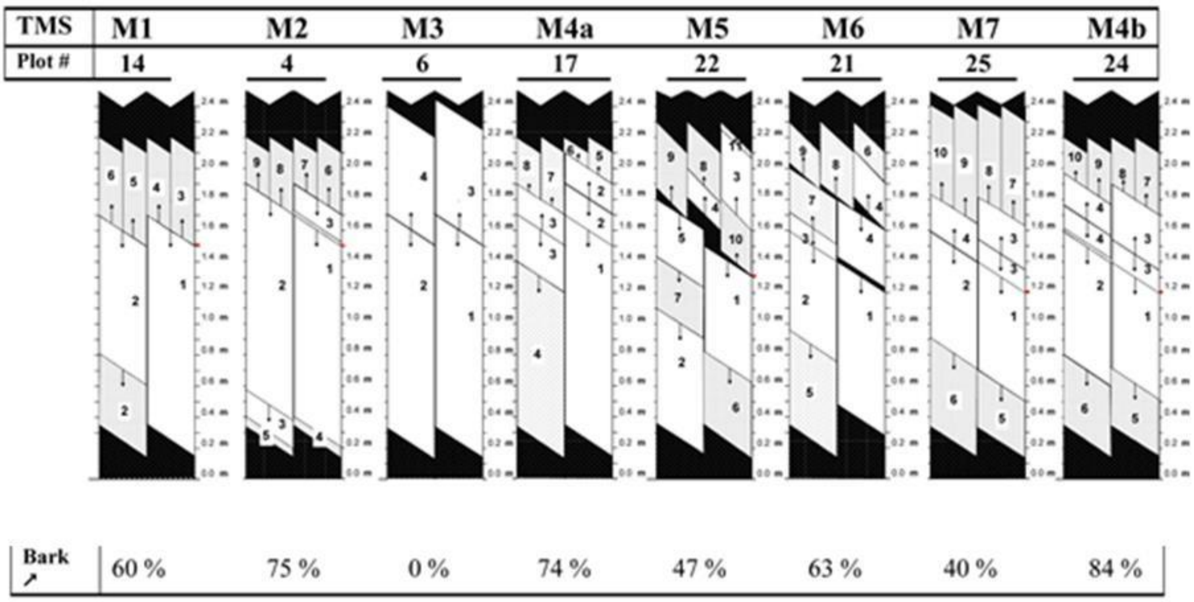

Fig. 2 Examples of tapping panel diagnosis performed on representative cases of tapping management variability and used as a tool to identify and test changes (cut length, panel succession and number of tapping cuts); the impact of intended changes was identified by measuring the increase in the height of tappable virgin bark (%, mean). TMS: Tapping Management Systems; Bark ↗: increase in virgin bark height; areas in white: panels of already consumed bark; lightly shaded areas: panel of virgin after adoption of changes; dark shaded areas: unusable bark.

Focusing the agronomic diagnosis on the economic lifespan of the plantation and not on yield or productivity only will improve yield in the long run.
Tapping panel diagnosis is a very visual decision-support tool, which will help smallholders identify a potential innovation and calculate its feasibility. It can consequently be used for participatory research purposes, to identify previous technical choices, to deduce the current potential of the plot, and to design innovating tapping management systems in accordance with the objectives of the smallholders. The simulation of the impact of tapping management systems on the sustainability of a plot is likely to be of interest to decision makers, both at the scale of a group of producers and of a whole supply basin.

4. Discussion and Conclusion

For smallholders, a rubber tree plantation is a major investment, and its sustainability is all the more crucial since the productive period is preceded by a 7-year unproductive immature period.

In conclusion:

- tapping panel diagnosis is easy to use and requires few resources, but will need to be adapted to each production area, in accordance with local practices or constraints such as maximum tapping height, which determines virgin bark potential, or the number of working days per week and the number of months tapping is interrupted during the year, which influence annual bark consumption.
- tapping panel diagnosis is an appropriate way to evaluate the impacts of tapping management specifications on the virgin bark availability, which is the production capital of the rubber tree.

The tapping panel diagnosis is an appropriate way to evaluate the impacts of tapping management specifications on the virgin bark availability, which is the production capital of the rubber tree. Other parameters, such as hormone stimulation, which influence the physiological status of trees, and the quality of tapping, which influences the likelihood of tapping regenerated bark, could also affect the economic sustainability of the rubber plantation. Although these parameters would be useful supplements in the diagnosis, we chose to base our tool on observable data that we considered reliable

This specification, which is seldom encountered in the diagnosis of tree plantations, makes this tool original. In the same way, focusing the agronomic diagnosis on the economic lifespan of the plantation and not on yield or productivity is also original. But we believe that changes suggested by the use of tapping panel diagnosis as a decision support tool should improve the physiological status of the trees and hence also improve yield in the long run.

Moreover, the tapping management system can be assessed, leading to simplified tapping panel management model (frequency and intensity) in accordance with:
- the status of bark activation (or fatigue) on downward panels BO-1 and BO-2
- the need to harvest more long time the virgin bark by tapping the upward panels

We consider the opportunity to having 3 successive tapping cycles in the life span of the rubber tree (Fig. 3):
- (i) conventional tapping on virgin bark (Fig. 3a):
- phase 1, downward tapping during at least 10 years in S/2,
- phase 2, upward tapping since the year 11 in S/4
- (ii) conventional tapping on renewed bark, less used because tapping cycles are shorter, most of the time 25 years instead of 35 years before (Fig. 3b)
- (iii) intensive tapping before slaughtering (Fig. 3c)

Regarding good latex harvesting practices, the possible recommended tapping system would ensure 22 years of tapping on virgin bark, integrating reversed quarter spiral tapping, in accordance with CIRAD recommendations.

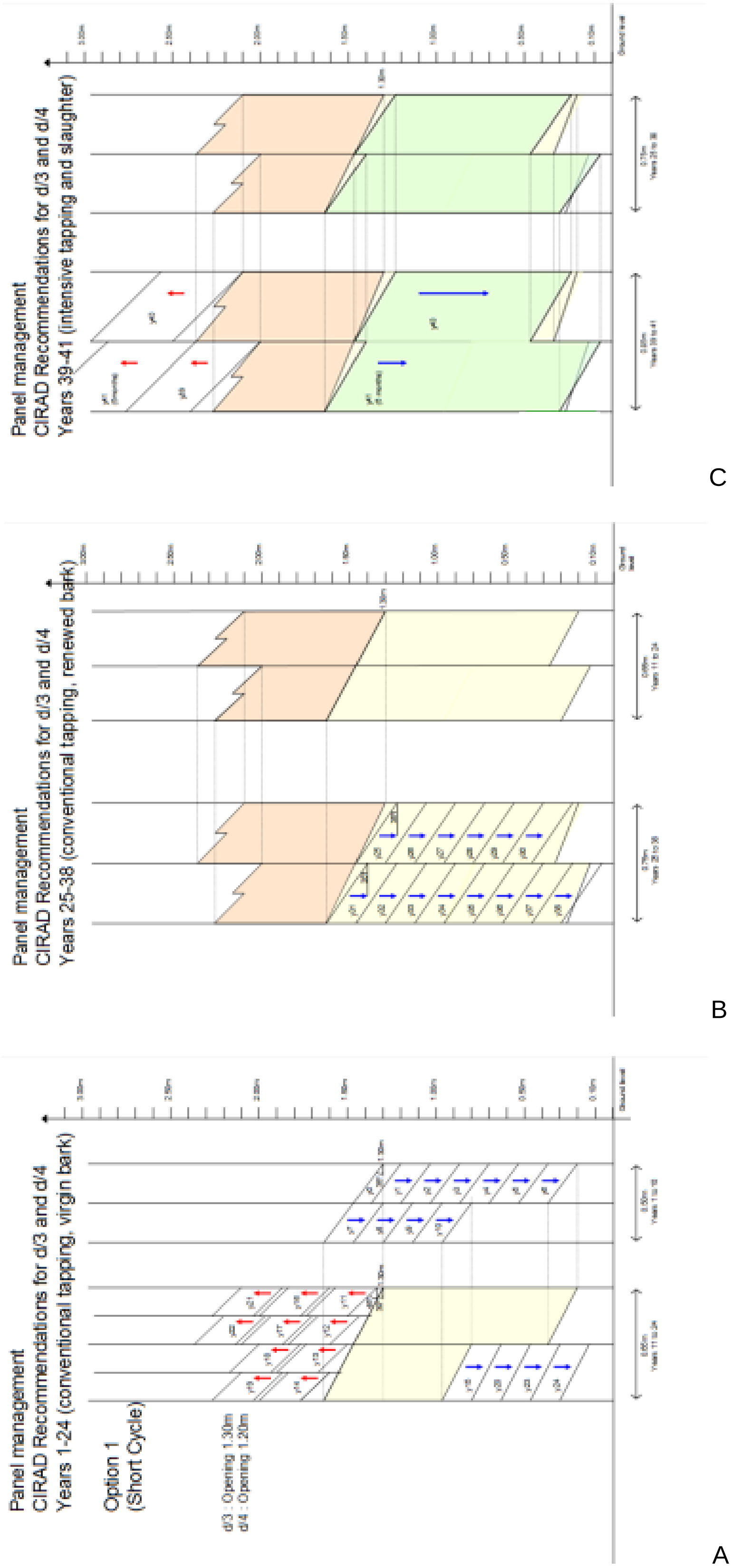

Fig 3: Tapping of the rubber tree, (A); downward tapping then upward tapping on virgin bark, (B); tapping on renewed bark, (C); intensive tapping both on renewed bark (downward) and on high virgin panel (upward).

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